Scheduling for Load Balancing on Machines In Flexible Manufacturing Systems (FMS)

Abstract

Scheduling of jobs in flexible manufacturing systems involves a complicated and complex evaluation of parameters in order to obtain an efficient sequence of processes to be carried on to ensure a continuous production. This is a time taking and tedious task as the set of parameters to be evaluated may range to a large number. It is a manufacturing system which possesses the flexibility of adopting its machines and factory environments according to the product to be produced. Though the flexibility in the manufacturing systems is an advantage it proves to be a very complicated task when it comes to scheduling of parts in a changing environment. The present study suggests an algorithm for solving the job shop scheduling problem. Traditional scheduling method does not keep up with the growing requirements of the customers and enterprises to produce the parts with low lead time low cost and instant procurement. To achieve this, an effective algorithm must be used such that an efficient processing sequence is obtained assuring load balance on the workstation is maintained in order to avoid heavy or under loading conditions and get use of the machines to a full throughput. The objective of this paper is to develop an algorithm and therefore coded in a software language with all the parameters considered. Necessary conditions are fed as in input to the program which then generates the optimized sequence as an output to be followed by executing the algorithm.

1. Introduction

Flexible manufacturing systems (FMS) are a group of machines most preferably CNC which are coordinated by a common control centre which has the ability to deal with the variety of products. It is a manufacturing system which possesses the flexibility of adopting its machines and factory environments according to the product to be produced. Though the flexibility in the manufacturing
systems is an advantage it proves to be a very complicated task when it comes to scheduling of parts in a changing environment. It has to be done keeping in view of the number of parts to be processed, the number of work stations and the number of individual machines in each work station, customer requirements and many other auxiliary set of variables are to be considered \[1\].

The objective of this paper is to develop an algorithm which can be applied in solving the problem of scheduling on a large scale with relative ease. Traditional scheduling method does not keep up with the growing requirements of the customers and enterprises to produce the parts with low lead time low cost and instant procurement. To achieve this, an effective algorithm must be used such that an efficient processing sequence is obtained assuring load balance on the work station is maintained in order to avoid heavy or under loading conditions and get use of the machines to a full throughput. It is further made Easy when the algorithm is coded into a software language which enables the operator perform scheduling task with relative ease by simply entering the job parameters and machining parameters as input and when the program is run with as guided by the algorithm the output will be a sequence to be followed in order to avoid uninterrupted production which is unfavorable to any enterprise \[2\].

![Structure of FMS](image)

**Figure 1: Structure of FMS**

2. Algorithm

When a new job enters the system, it must declare the maximum number of machines of each work station that it may need for its processing. This number must not exceed the total number of machines in the system. When a job requests a set of machines, the system must determine whether the allocation of these machines to that job will leave the system in a safe state. If it will, they are allocated; otherwise, the job must wait until some other jobs get process. Data structures are maintained to govern the above activities to store and retrieve the functions when required. Some data structures we use in our algorithm:
Available: A vector of length m indicates the number of available machines of each cell. If available[j] equals k, there are k instances of machines available in station available.

Max: A n*m matrix defines the maximum demand of each job. If Max[i][j] equals k, then job Ji may request at most k instances of station.

Allocation: An n*m matrix defines the number of jobs of each type currently allocated to each machine. If allocation[i][j] equals k, then job is currently allocated k instances of station.

Need: An n*m matrix indicates the remaining machines need of each job. If Need[i][j] equals k, then job may need k more instances of station to complete its task.

3. Problem Statement

The objective of this paper is to develop an algorithm and encode it in a software language (C) which can be applied in solving the problem of scheduling on a large scale with relative ease. Traditional scheduling method does not keep up with the growing requirements of the customers and enterprises to produce the parts with low lead time, low cost, and instant procurement. To achieve this, an effective algorithm must be used such that an efficient processing sequence is obtained assuring load balance on the work station is maintained in order to avoid heavy or under loading conditions and get use of the machines to a full throughput.

It is further made easy when the algorithm is coded into a software language which enables the operator perform scheduling task with relative ease by simply entering the job parameters and machining parameters as input and when the program is run with as guided by the algorithm the output will be a sequence to be followed in order to avoid uninterrupted production. When a new job enters the system, it must declare the maximum number of machines of each work station that it may need for its processing. This number must not exceed the total number of machines in the system. When a job requests a set of machines, the system must determine whether the allocation of these machines to that job will leave the system in a safe state. If it will, they are allocated; otherwise, the job must wait until some other jobs get processed.
4. Program

```c
#include <stdio.h>
#include <stdlib.h>
int main()
{
    int Max[10][10], need[10][10], alloc[10][10], avail[10], completed[10], safe Sequence[10];
    int p, r, i, j, jobs, count;
    count = 0;

    printf("Enter the no of jobs : ");
    scanf("%d", &p);

    for(i = 0; i < p; i++)
        completed[i] = 0;

    printf("\n\nEnter the no of machines : ");
    scanf("%d", &r);

    printf("\n\nEnter the Max Matrix for each jobs: ");
    for(i = 0; i < p; i++)
        for(j = 0; j < r; j++)
            scanf("%d", &Max[i][j]);

    // Further code for scheduling

    return 0;
}
```
printf("nFor jobs %d : ", i + 1);
for(j = 0; j < r; j++)
    scanf("%d", &Max[i][j]);
}

printf("n
Enter the allocation for each jobs : ");
for(i = 0; i < p; i++)
    { Printf ("n For jobs %d : ", i + 1);
      for(j = 0; j < r; j++)
         scanf("%d", & alloc [i][j]);
    }

printf("n
Enter the Available machines : ");
for(i = 0; i < r; i++)
   scanf("%d", &avail[i]);

for(i = 0; i < p; i++)
   for(j = 0; j < r; j++)
      need[i][j] = Max[i][j] - alloc[i][j];

do
 { printf("n Max matrix:	Allocation matrix:\n");
   for(i = 0; i < p; i++)
     { for( j = 0; j < r; j++)
         printf("%d ", Max[i][j]);
         printf("\n");
         for( j = 0; j < r; j++)
         printf("%d ", alloc[i][j]);
         printf("\n");
     }

   jobs = -1;

   for(i = 0; i < p; i++)
     { if(completed[i] == 0)/if not completed
       { jobs = i ;
         for(j = 0; j < r; j++)
           { if(avail[j] < need[i][j])
             { jobs = -1;
               break;
             }
          }
        }
      }
   }
   jobs = -1;
if(jobs != -1)
        break;
    }

if(jobs != -1)
{
    printf("\n jobs %d runs to completion!", jobs + 1);
    safeSequence[count] = jobs + 1;
    count++;
    for(j = 0; j < r; j++)
    {
        avail[j] += alloc[jobs][j];
        alloc[jobs][j] = 0;
        Max[jobs][j] = 0;
        completed[jobs] = 1;
    }
}
}
while(count != p && jobs != -1);

if(count == p)
{
    printf("\nThe system is in a safe state!!\n");
    printf("Safe Sequence : < ");
    for(i = 0; i < p; i++)
        printf("%d ", safeSequence[i]);
    printf(">
");
}
else
    printf("\nThe system is in an unsafe state!!");

5. Output
Enter the no of jobs  : 5
Enter the no of jobs  : 3
Enter the Max Matrix for each jobs :
For jobs 1 : 7
5
3
For jobs 2 : 3
2
2
For jobs 3 : 7
0
2
For jobs 4 : 2
2
2

For jobs 5: 4
3
3
Enter the allocation for each jobs:
For jobs 1: 0
1
0
For jobs 2: 2
0
0
For jobs 3: 3
0
2
For jobs 4: 2
1
1
For jobs 5: 0
0
2
Enter the Available machines: 3
3
2
Max matrix: Allocation matrix:
7 5 3 0 1 0
3 2 2 2 0 0
7 0 2 3 0 2
2 2 2 2 1 1
4 3 3 0 0 2
Jobs 2 runs to completion!
Max matrix: Allocation matrix:
7 5 3 0 1 0
0 0 0 0 0 0
7 0 2 3 0 2
2 2 2 2 1 1
4 3 3 0 0 2
Jobs 3 runs to completion!
Max matrix: Allocation matrix:
7 5 3 0 1 0
0 0 0 0 0 0
0 0 0 0 0 0
2 2 2 2 1 1
4 3 3 0 0 2
Jobs 4 runs to completion!
Max matrix: Allocation matrix:
7 5 3 0 1 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 0 0
4 3 3 0 0 2
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6. Results

The necessary parameters when given to the program as input which includes the set containing the total number of jobs, work stations and the machines in each work station, status of maximum, currently allocated, available machines on the work floor and other miscellaneous factors like processing time limit, instances of each machine when are executed the output obtained is a sequence of jobs to processed so as to avoid any kind of deadlock and breakdown on the shop floor. Therefore for effective results and optimized usage of machines on the shop floor the scheduling has to be done according to the sequence obtained by as the output by the program. If at all there is no proper sequence which can be generated by the program for the given set of values then it generates an incomplete sequence of jobs to be processed up to which no blocking or starving conditions prevail in the system leaving the system in a safe operating state. It notifies that the processing of immediate next job after this sequence may lead to a blocking or starving leaving the system in an unsafe state. Additionally an avoidance algorithm can be used to solve these kinds of situations.

7. Conclusion

Optimization procedure has been developed in this work which is based on banker’s algorithm and is implemented successfully for solving the scheduling optimization problem of FMS. Codes are written in C++ language. Results are obtained for n jobs and m machines in the system. With less computational effort it is possible to obtain the solution for such a large number of jobs and machines .This work leads to the conclusion that the procedures developed in this work can be suitably modified to any kind of FMS with a large number of components and machines subject to multi objective functions. If research carried on the algorithm and re writing of the program in other advanced software languages its application can be implemented in a variety of fields which will include availability and handling times of loading/unloading stations, robots and AGVs.

8. Future Scope

I. Multi objective scheduling for FMS can be done by further development of the algorithm unlike only job shop scheduling done here.

II. A deadlock prevention phenomenon is applied in this paper which can be more sophisticated by applying deadlock avoidance strategy.

III. The algorithm written here is coded in C++ language which when coded in a further sophisticated software language the capability, accessibility and responsive speed can be enhanced.

IV. The coded language when interfaced with animation software like FLEXSIM and AUTOMOD the visual experience can also provided

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References

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